Predictors of Pitch Velocity in Youth and Professional Baseball Pitchers

INTRODUCTION

In baseball, the predominant pitch is the fastball and the ability to maximize fastball velocity is often the determining factor for experiencing long-term success. The purpose of this study was to identify those variables predicting pitch velocity within each group. An additional purpose of this study was to compare those variables identified as predictors of pitch velocity between the two groups. It was hypothesized that the variables predicting pitch velocity would be similar between the groups.

METHODS

Forty-one healthy baseball pitchers (25 professional and 16 youth) served as participants in this study. Data collection and analysis was conducted with techniques previously established and testing protocols were approved by the Regis University (Denver, CO) Institutional Review Board.

Each participant threw a series of maximal effort pitches which were recorded for later analysis. Digitization of the movement began .5 seconds prior to ball/glove separation and continued through .5 seconds after the instant of ball release. The three-dimensional location of each digitized landmark was calculated using Direct Linear Transformation. Standard techniques were employed to calculate the throwing motion and calculations were performed using the three-dimensional marker coordinates from each frame of video. Inverse dynamics techniques were used to calculate shoulder and elbow joint kinetics with the ball and arm being modeled as four rigid links in series and connected by ball-and-socket joints. Joint forces (% bodyweight) and torques (% bodyweight*height) were then normalized and calculated along or about the anterior/posterior, medial/lateral, and proximal/distal axes.

Data on the fastest pitch passing through the strike-zone was analyzed for each pitcher. For both groups, separate backward stepwise regression analyses were conducted at foot contact (FC), maximum external rotation (MER), ball release (BR), and maximum internal rotation (MIR). All variables not identified as significant at these moments were removed from the regression model and a final analysis was conducted on the remaining variables. Because five regression models were used on data derived from the same group of participants, the level of significance was set at p < 0.01.

RESULTS

Results of the regression analyses (Tables 1 & 2) indicated that for both groups, ball velocity could be predicted from a combination of a number of variables. However, the variables predicting pitch velocity were different for both groups, and the percentage of ball velocity variance explained by the regression models was much higher for youth pitchers. In youth pitchers, ball velocity could be predicted from a linear combination of kinetic parameters at MER (shoulder abduction angle, elbow extension velocity, and shoulder rotational velocity) and kinetic parameters at BR (shoulder compressive force, shoulder internal rotation torque, and elbow flexion torque). This stepwise regression model explained 93% of the variance (r=.966, r²=.933) in ball velocity.

Although analysis of professional pitchers identified no significant kinematic predictors of pitch velocity, the regression model did identify three significant kinetic predictors of pitch velocity. At BR, ball velocity could be predicted from a linear combination of both elbow medial and compressive forces, and shoulder horizontal abduction torque, and this stepwise regression model explained 63% of the variance (r=.792, r²=.628) in ball velocity.

DISCUSSION

No variables retained by the final regression models were similar across the two groups. Although the variables were different between groups, a finding that is of particular interest is that the final regression model in youth pitchers retained three kinematic variables, while the final professional model retained no kinematic variables.

Upon closer examination of the youth model, a relationship between several of the retained variables can be observed. Shoulder compressive force at BR was retained as a significant predictor of pitch velocity. It stands to reason that this is the result of the angle of shoulder abduction at MER being retained by the model. Because alterations in the angle of shoulder abduction produce changes in the distracting forces experienced by the glenohumeral joint, corresponding changes in shoulder compressive forces (the force resisting distraction of the glenohumeral joint) should be observed.

A similar relationship can be observed in the retained variables that describe movements at and about the elbow throughout the pitch cycle. Both shoulder rotational velocity and elbow flexion torque were identified as significant predictors of pitch velocity by the youth model. Shoulder rotation velocity has previously been shown to impact the rate of elbow extension by altering the centrifugal force transmitted down the length of the arm during pitching. Changes in this parameter, along with changes in the magnitude of elbow flexion torque (which opposes elbow extension during arm cocking and arm acceleration) should have a direct impact on the velocity with which the elbow extends throughout the pitch cycle.

An additional finding of this study that is of interest is that the final youth regression model explained a much higher percentage of the variance (r=.966, r²=.933) in ball velocity than did the final professional regression model (r=.792, r²=.628). One reason for this may be the number of variables retained by the final regression models. By retaining the three additional kinematic variables, the youth model was able to include a larger percentage of the movements involved in completing the pitch cycle; and thus, explain a much higher percentage of ball velocity variance.